(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 468 319 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent: **08.05.1996 Bulletin 1996/19**

(51) Int Cl.^{6}: **H01S 3/00**, H01S 3/094, H01S 3/0941, H01S 3/25, G02B 6/28, G02B 6/42

(21) Application number: **91111671.3**

(22) Date of filing: **12.07.1991**

(54) Laser generating apparatus

Lasergenerator

Générateur laser

(84) Designated Contracting States:
DE FR GB

(30) Priority: **19.07.1990 JP 191152/90**

(43) Date of publication of application:
29.01.1992 Bulletin 1992/05

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention generally relates to laser generating apparatus, and more particularly, is directed to an end pumped solid-state laser and pumping source thereof.

Description of the Prior Art

Conventionally, a laser light source is employed in order to efficiently pump or excite a solid-state laser.

More specifically, in a prior-art side pumping method where a laser light source is pumped from a side face of a solid state laser rod such as Nd:YAG as shown in FIG. 1, a light resonator is composed of respective side faces of, for example, a cylindrical laser medium or laser rod 1. From the laser light source, a pumping or exciting light L1 is incident in the direction perpendicular to an axis O of the light resonator, that is, onto the side face of the laser rod 1.

The above-mentioned structure provides a wider area which is irradiated with the pumping light L1, whereby the whole light quantity of the pumping light L1 incident to the laser rod 1 can be correspondingly augmented, so that a laser light L0 having a large light intensity as a whole can be emitted from the laser rod 1. However, the side pumping method is difficult to obtain a laser light L0 of a spot of short diameter.

For this reason, an end pumping method is employed for obtaining a laser light of a short spot diameter, where a pumping light L2 is incident to a laser rod 3 from the end face thereof to pump the same, as shown in FIG. 2. More specifically, mirrors 4, 5 are disposed in the vicinity of respective end faces of the laser rod 3, whereby a light resonator is formed as a whole for a laser light L0 emitted from the laser rod 3.

Further, the mirror 4 selectively transmits the pumping light L2, while the mirror 5 transmits a part of the laser light L0 and reflects the rest of the same, whereby the pumping light L2 is incident on one end face of the laser rod 3 through the mirror 4 to pump or excite the laser rod 3. The laser light L0 resonated by the light resonator composed of the mirrors 4, 5 is emitted through the mirror 5.

With the above structure, a region of the laser rod 3 on which the pumping light L2 is incident is pumped, whereby a laser light is induced and then emitted from this pumped region. It is therefore possible to generate a laser light L0 of a short spot diameter by reducing the beam diameter of the pumping light L2. Thus, a light beam emitted, for example, from a laser diode is incident to an end face of a laser rod as a pumping light to thereby generate a desired laser light LO from the laser rod.

For generating a laser light L0 with a short beam diameter and a large light quantity by pumping a laser rod with a pumping light by the end pumping method, it is necessary to pump the laser rod 3 with a pumping light L2 having a short beam diameter and a large light quantity, that is, a pumping light L2 having a large power density.

However, the laser diode can merely generate a light beam having approximately 1 W at present, and therefore it is a future problem how to enhance the intensity of the pumping light.

Though the end pumping method can generate the laser light L0 of a short spot diameter, it cannot efficiently pump a laser rod, thereby presenting a difficulty in enhancing the intensity of the laser light L0.

There has been proposed as one of the solutions for this problem a method of generating a pumping light having a large light quantity by using an optical fiber bundle 7 as illustrated in FIG. 3 (OPTICS LETTERS/Vol. 13, No. 4/April 1988, pp 306 - 308, Fiber-bundle coupled, end pumped Nd:YAG laser).

More specifically, light beams emitted from laser diodes 8A - 8N are led to respective optical fibers constituting the fiber optics bundle 7 to thereby guide and converge the light beams from the laser diodes 8A - 8N by means of the fiber optics bundle 7. Then, a pumping light L3, which is appropriately converged for pumping a laser rod 12, is generated through lenses 9 and 10. The laser rod 12 is formed with a mirror surface on one end face thereof on the side of the fiber optics bundle 7 for selectively transmitting the pumping light L3, thereby forming an optical resonator by the end face having the mirror surface and a mirror 5.

Since the light beams emitted from the laser diodes 8A - 8N are converged by the fiber optics bundle 7, the light quantity of the pumping light L3 is enhanced. Thus, if the light beams from a plurality of the high-output laser diodes are converged by the fiber optics bundle 7 to generate the pumping light L3, a laser light having a short spot diameter and a high light intensity can be emitted.

On the other hand, a high-output laser diode features in a large stripe width which may be, for example, 100 µm. For delivering a light beam outputted from such a laser diode to an optical fiber, it is necessary to employ an optical fiber having a diameter larger than the stripe width of the high-output laser diode, which is required by an optical coupling. As the result, the whole diameter of the fiber optics bundle 7 becomes larger, which leads to increase the beam diameter of the pumping light L3 outputted from the fiber optics bundle 7. Thus, the pumping light L3 having a large light intensity is provided, whereas the spot diameter of the pumping light L3 is larger, thereby presenting a difficulty in improving the power density.

Although a laser light having a large light intensity can be generated by applying the pumping light L3 to the end pumping method, the spot diameter of the laser light pumped by the pumping light L3 becomes larger corresponding to the spot diameter thereof.

In the patent application GB-2,182,168 A and in the article "Diffraction-limited circular single spot from phased array lasers" (Applied Optics **28**, 4560, November 1, 1989) there are described phase-coupled laser array systems, where a two lobe field pattern emitted from the phase-coupled laser array is converted into a single lobe light beam by means of a polarizing beam splitter, whereby the polarizing plane of one of the two lobes has been rotated by 90 degrees. A single lobe light beam emitted from this polarizing beam splitter is then reshaped from a flat ellipse to an ellipse close to a circle by means of anamorphic prisms.

However this configuration is not applicable to laser light sources where high power densities are required. The transmittance of the anamorphic prism is at its maximum level only for one specific incident angle (brewster angle) of the polarization plane with respect to the surface of the anamorphic prism. Since the single lobe light beam emitted from the polarizing beam splitter comprises light with different polarization planes, maximum transmittance of the anamorphic prism cannot be achieved for the whole light beam.

WO-A-91/12641 which describes a solid state laser diode light source, forms state of the art pursuant to Articles 54(3) and (4) EPC, meeting the requirements of Article 158(2) EPC.

OBJECTS AND SUMMARY OF THE PRESENT INVENTION

It is a first object of the present invention to provide a laser light source exhibiting a high power density.

It is another object of the present invention to provide a laser light source having a short spot diameter.

It is a further object of the present invention to provide a solid-state laser exhibiting a high power density by using the above-mentioned laser light source.

It is an additional object of the present invention to provide a solid-state laser having a short spot diameter by using the above-mentioned laser light source.

The present invention is directed to an end-pumped solid-state laser and a laser light source for its pumping, wherein a couple of optical beams having respective beam shapes re-formed and polarizing planes arranged perpendicular to each other are synthesized by a polarizing beam splitter and thereafter led to an optical guide such as an optical fiber through a predetermined optical system, thereby generating a synthesized light having a short spot diameter and an improved power density and providing an end-pumped solid-state laser by pumping a laser by this synthesized light.

More specifically, to solve the problems mentioned above, the present invention provides a laser light source comprising first and second light sources for emitting first and second light beams respectively having a predetermined polarizing plane, first anamorphic beam shape re-form means for re-forming the beam shape of the first light beam, second anamorphic beam shape re-form means for re-forming the beam shape of the second light beam, and a polarizing beam splitter coupled to receive a first light beam outputted from the first anamorphic beam shape re-form means and a second beam outputted from the second anamorphic beam shape re-form means which has the polarizing plane inclined by 90 degrees relative to the first beam. A synthesized light outputted from the polarizing beam splitter is supplied to an optical guide such as an optical fiber to pump a laser rod to thereby generate a laser light. Incidentally, the synthesized light outputted from the polarizing beam splitter may be supplied to an optical fiber through an optical system for converging a light comprising relay lenses.

The present invention constructed as described above reforms the beam shapes of light beams and may supply the re-formed light beams to an optical guide such as an optical fiber, whereby an optical guide of a short spot diameter can be employed.

The first and second light beams are synthesized by the polarizing beam splitter in a state where the polarizing planes thereof are different by 90 degrees with each other and may be led to the optical fiber, thereby generating a laser light of a short spot diameter as well as a synthesized light with an improved power density.

The above and other objects, features, and advantages of the present invention will become apparent from the following detailed description of illustrative embodiments thereof to be read in conjunction with the accompanying drawings, in which like reference numerals are used to identify the same or similar parts in the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram illustrating a side pumping method;

FIG. 2 is a schematic diagram illustrating an end pumping method;

FIG. 3 is a schematic diagram showing how a laser light is pumped by using a fiber optics bundle;

FIG. 4 is a block diagram illustrating a laser apparatus in which the present invention is implemented;

FIG. 5 is a block diagram illustrating a first embodiment of a laser source according to the present invention;

FIG. 6 is a schematic diagram illustrating a spot of a light beam emitted onto an end face of an optical fiber in the first embodiment of the present invention;

FIG. 7 is a block diagram illustrating a second embodiment of a laser light source of the present invention;

FIG. 8 is a block diagram illustrating an arrangement of a third embodiment of the laser light source according to the present invention;

FIG. 9 is a diagram illustrating spots of light beams on an end face of an optical fiber used in the third

embodiment of the present invention; and

FIG. 10 is a diagram illustrating an arrangement of a fourth embodiment of the laser light source according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described in detail with reference to the accompanying drawings.

FIG. 4 illustrates a laser apparatus 20 in which the present invention is implemented, where like parts corresponding to those of FIG. 3 are marked with the same reference numerals and therefore need not be described. In brief, in this embodiment, laser lights emitted from laser light sources 21A - 21N are converged to generate a pumping or exciting light.

FIG. 5 illustrates a part of the laser light source employed in a first embodiment of the present invention. As shown in FIG. 5, each of the laser light sources 21A - 21N shown in FIG. 4 has laser diodes 22A and 22B for emitting light beams LA and LB having an intensity of, for example, 1 W. In this embodiment, the laser diodes 22A and 22B are disposed such that the directions of stripes for emitting lights are both oriented in parallel with the surface of the sheet of drawing and the optical axes of the optical beams LA and LB are perpendicular to each other. Thus, the light beams LA and LB emitted from the laser diodes 22A and 22B are such that the polarizing planes thereof are in parallel to the surface of the sheet of drawing as indicated by arrows a and b and the beam shape thereof is an ellipsoid where the respective beams extend over an angle of, for example, approximately 10 degrees in the direction parallel to the surface of the sheet of drawing and over 30 degrees in the direction vertical to the same.

On the optical axes of the respective laser diodes 22A and 22B, there are disposed collimator lenses 23A and 23B, respectively, to convert the light beams LA and LB to parallel light beams. Further, on the optical axes of the collimator lenses 23A and 23B, there are disposed anamorphic prisms 28A and 28B respectively composed of two prisms 25A, 25B and 26A, 26B mounted on glass substrates 24A, 24B. These anamorphic prisms 28A and 28B re-form each of the shapes of the light beams LA and LB from a flat ellipse to an ellipse close to a circle. Incidentally, when the magnifications of the anamorphic prisms 28A and 28B were selected to be approximately 2.5, the beam shapes of the light beams LA and LB were changed from the flat ellipse to the ellipse close to a circle.

On the optical axis of the anamorphic prism 28A there is disposed a half-wave plate 30 with the a polarizing plane thereof being inclined by 45 degrees relative to the light beam LB, whereby the polarizing plane of the light beam LB is offset by 90 degrees from the polarizing plane of the light beam LA.

Thus, generated are the light beam LB having an elliptic beam shape close to a circle and the polarizing plane oriented vertical to the surface of the sheet of drawing and the laser beam LA having an elliptic beam shape close to a circle in a manner similar to the light beam LB and the polarizing plane and the optical axis perpendicular to those of the light beam LB.

Further, on the optical axis of the anamorphic prism 28A and the half-wave plate 30, there is disposed a polarizing beam splitter (PBS) 32 at a position where the optical axes of the light beams LA and LB cross so as to synthesize the light beams LA and LB.

The polarizing beam splitter 32 has the properties of transmitting a p-wave but reflecting an s-wave. It will be understood that the light beam LA is transmitted through the polarizing beam splitter 32 while the light beam LB, the optical axis of which is perpendicular to that of the light beam LA, is polarized by 90 degrees by the polarizing beam splitter 32, whereby a synthesized light LL is generated by coinciding the optical axes of the light beams LA and LB with each other.

The light LL thus synthesized by coinciding the optical axes of the light beams LA and LB and shaped in an ellipse close to a circle, exhibits a light intensity approximately double that of the light beam LA or LB and accordingly a higher power density compared with the light beams LA and LB.

In addition, since the two light beams LA and LB having their polarizing planes perpendicular to each other are synthesized by the polarizing beam splitter 32, the synthesized light LL can be generated while effectively avoiding the interference between the two light beams LA and LB.

FIG. 6 illustrates a beam spot shape on an end surface of an optical fiber connected to an optical connector 37 shown in FIG. 5. The respective beam spots of the light beams LA and LB are formed in a substantially identical region on the end surface of the optical fiber.

The anamorphic prism generally has the characteristic of changing the transmittance in accordance with polarizing planes. Specifically, the anamorphic prisms 28A, 28B exhibit substantially 100% of transmittance for a polarizing plane parallel to the surface of the sheet of drawing while produce a loss of approximately 10% for a polarizing plane vertical to the surface of the drawing paper. For this reason, after the beam shape has been re-formed, the polarizing plane is polarized by 90 degrees through the half-wave plate 30 to thereby generate the synthesized light LL presenting a large power density.

Then, the synthesized light LL is converted to a parallel light by relay lenses 34 and 35 and led to a collimator lens 36, whereby eclipse of the synthesized light LL is avoided.

The collimator lens 36 converges the incident synthesize light LL and leads the same to the optical connector 37, whereby the synthesized light LL is incident to an optical fiber connected to the optical connector 37. The synthesized light LL can be thus efficiently led to

optical fibers 40A - 40N of a short diameter (see FIG. 4) through the optical system composed of the relay lenses 34, 35 and collimator lens 36.

In the present embodiment, the magnification A of the anamorphic prisms 28A and 28B is selected to be 2.5 so as to re-form the shape of the light beams LA and LB from a flat ellipse to an ellipse close to a circle, thereby reducing the spot size of the synthesized light LL when it is incident to the optical fiber.

The present embodiment employs the laser diodes 22A and 22B, the stripe width of which is 200 μm to synthesize the light beams LA and LB emitted from the laser diodes 22A and 22B. Also, the anamorphic prisms 28A and 28B provide a reduced size of the spot on the end surface of the optical fiber connected to the optical connector 37. More specifically, with the magnification A selected to be 2.5, as mentioned above, the spot size is reduced as given by the following equation:

$$200\ \mu m/A = 200\ \mu m/2.5 = 80\ \mu m$$

Thus, the synthesized light LL having the spot size reduced to 80 μm is supplied to the optical fiber, the diameter of which is 100 μm. It is therefore possible to provide a light density several times higher as compared with a case where the synthesized light LL is directly incident to an optical fiber with the diameter of 200 μm.

The optical fibers 40A - 40N shown in FIG. 4 form a bundle so as to converge the synthesized lights LL emitted from the respective laser light sources 21A - 21N and pump the laser rod 12 on the end surface thereof by the converged synthesized light. The laser rod 12 can be thus pumped on the end surface thereof by the synthesized light LL having a short spot diameter and an improved power density, whereby the laser light L0 correspondingly having a short spot diameter and a large light intensity is emitted.

In the present embodiment, the laser diodes 22A and 22B constitute first and second light sources for emitting the first and second light beams LA and LB respectively having a predetermined polarizing plane. The anamorphic prisms 28A and 28B in turn constitute first and second beam shape re-forming means for re-forming the shape of the first and second light beams LA and LB. Also, the relay lenses 34, 35 and the collimator lens 36 constitute an optical system for converging the synthesized light LL outputted from the polarizing beam splitter 32 and leading the converged synthesized light to the optical fiber.

According to the above described structure, the light beams LA and LB having the beam shapes re-formed and the polarizing planes perpendicular to each other are synthesized by the polarizing beam splitter 32 and then led to the optical fiber through a predetermined optical system, thereby making it possible to provide a laser light having a shorter spot diameter and an improved power density.

FIG. 7 illustrates a laser light source of a second embodiment of the present invention, where like parts corresponding to those of FIG. 5 are marked with the same reference numerals. A laser light source, generally indicated by 60 in FIG. 7, emits a synthesized light LL to an optical connector 37. A laser rod is pumped by the synthesized light LL to emit a laser light.

More specifically, the laser light source 60 has prisms 25A, 25B and 26A, 26B respectively constituting anamorphic prisms 28A, 28B, the half-wave plate 30 and the polarizing beam splitter 32 mounted on a glass substrate 41, whereby the overall size of the light source is reduced.

Further, the prism 26A, the polarizing beam splitter 32, the half-wave plate 30 and the prism 26B are integrated on their light incident and emitting faces, which are parallel to each other by abutting, contacting, etc., whereby the size of the glass substrate 41 is reduced and accordingly the overall size of the laser light source 60 is further reduced. If the prisms 26A, 26B, the half-wave plate 30 and the polarizing beam splitter 32 are thus integrally formed by bonding or the like, a coating process for preventing reflection can be removed on the contacting surfaces of the the prisms 26A, 26B, the half-wave plate 30 and the polarizing beam splitter 32, thereby making it possible to provide the laser light source 60 of a correspondingly simple structure as a whole. Such reduction of the overall size of the laser light source 60 by mounting the prisms 25A, 25B and 26A, 26B, the half-wave plate 30 and the polarizing beam splitter 32 on the single glass substrate 41 also results in reducing the optical path from the laser diodes 22A, 22B to the optical connector 37.

Reference numeral 44 denotes the optical system for converging the synthesized light beam out-putted from the polarizing beam splitter 32 as described above.

According to the structure shown in FIG. 7, the prisms 25A, 25B, 26A and 2GB, the half-wave plate 30 and the polarizing beam splitter 32 are mounted on the single glass substrate 41 and the opposing surfaces thereof are brought into contact by the bonding-process, whereby a much simpler and smaller-sized laser light source 60 can be provided in addition to the effects produced by the first embodiment.

While the second embodiment shown in FIG. 7 has been discussed for the case that, after the light beams LA and LB, the polarizing planes of which are parallel to the surface of the sheet of drawing, are respectively emitted from the laser diodes 22A and 22B, the polarizing plane of the light beam LB is polarized by 90 degrees by the half-wave plate 30 through the anamorphic prisms 28A, 28B, the present invention is not limited to this specific embodiment. Alternatively, after the light beams LA and LB, the polarizing planes of which are vertical to the surface of the sheet of drawing, are respectively emitted from the laser diodes 22A and 22B, the polarizing plane of the light beam LA may be polarized by 90 degrees with respect to the polarizing plane of the light beam LB by the half-wave plate 30.

Also, instead of emitting from the laser diodes 22A

and 22B the light beams LA and LB, the polarizing planes of which are coincident with each other, the laser diode 22B and the anamorphic prism 28B may be disposed with inclination of 90 degrees therebetween, whereby the half-wave plate 30 may be removed.

FIG. 8 illustrates a third embodiment of the laser light source of the present invention, where like parts corresponding to those shown in FIG. 5 are marked with the same reference numerals. In the embodiment shown in FIG. 8, the half-wave plate 30 shown in FIG. 5 is removed, a laser diode 22B emits a laser beam in an elliptic shape which extends over approximately 10 degrees in the direction perpendicular to the surface of the sheet of drawing indicated by c and over approximately 30 degrees in the direction parallel to the same, and an anamorphic prism 28B is deviated by 90 degrees about the optical axis.

Therefore the polarizing plane of a light beam LA (p-polarizing light) from the laser diode 22A is perpendicular to the polarizing plane of a light beam LB (s-polarizing light) from the laser diode 22B. The shapes of these light beams LA, LB are re-formed respectively by anamorphic prisms 28A, 28B in an ellipse close to a circle and then synthesized by a polarizing beam splitter 32. It will therefore be understood from FIG. 9 that elliptic beam spots SPa, SPb of the light beams LA, LB on an end surface of an optical fiber connected to an optical connector 37 have the major axes substantially perpendicular to each other. In the laser light source shown in FIG. 5, on the contrary, beam spots SPa, SPb of the light beams LA, LB on the end surface of the optical fiber connected to the optical connector 37 have the major axes oriented in the same direction as shown in FIG. 6. The rest of the structure shown in FIG. 8 is the same as the embodiment shown in FIG. 5.

The third embodiment shown in FIG. 8 is advantageous over the embodiment shown in FIG. 5 in that a speckle noise (modal noise) due to the optical fiber is reduced, and the half-wave plate is not needed to thereby further simplify the structure.

Next, the speckle noise (modal noise) will be discussed. The speckle noise (modal noise) σm^2 is given by:

$$\sigma m^2 = \{Fc^2/(Fc^2+2Fs^2)\}\cdot\{(1-P)/P\}/Np$$

where Fc represents a fiber bandwidth, Fs a laser line width, P a coupling efficiency, and Np a number of pumping modes. It will be understood from the above equation that the third embodiment shown in FIG. 8 reduces the speckle noise (modal noise) since the number of pumping modes is increased, as compared with the embodiment shown in FIG. 5.

While the above embodiments have been discussed for the case that the synthesized light LL with the same wavelength is converged by the optical fibers, the present invention is not limited to this specific case. Alternatively, it is possible that, after a synthesized light may be generated from light beams with different wavelengths from each other by the aforementioned laser light source, it is converged, for example, by a dichroic mirror and led to an optical fiber.

FIG. 10 illustrates a fourth embodiment of the present invention in which respective laser light sources 50, 51, 52 are constructed in the same manner as the laser light sources employed in the above-mentioned embodiments. More specifically, light beams emitted from a couple of laser diodes are synthesized by a polarizing beam splitter, and synthesized light LL1, LL2, LL3, respectively having wavelengths of 780 nm, 810 nm, 830 nm are generated.

The synthesized lights LL1, LL2, LL3 are further synthesized through a mirror 54 and dichroic mirrors 55, 56 such that the optical axes of the respective synthesized lights LL1, LL2, LL3 are coincident with one another.

With such a structure, it is possible to generate the synthesized lights LL1, LL2, LL3 having shorter beam diameters and larger light quantities as compared with the prior art as well as supply synthesized lights respectively having a different wavelength to a single optical fiber.

While the above embodiments have been described for the case that a predetermined laser rod is pumped to generate a laser light, the present invention is not limited to such specific embodiments and the synthesized laser light emitted from the laser light source can be widely applied to a laser printing, a laser soldering, a laser machining, a laser scalpel, or the like.

While several preferred embodiments of the present invention have been described in detail hereinabove, many modifications and variations thereof would be apparent to those skilled in the art without departing from the scope of the present invention, which is to be defined by the appended claims.

Claims

1. A laser light source comprising:

a first light source (22A) for emitting a first light beam (LA) having a predetermined polarizing plane;
a second light source (22B) for emitting a second light beam (LB) having a predetermined polarizing plane;
first anamorphic beam shape re-form means (28A) for re-forming the beam shape of said first light beam (LA);
second anamorphic beam shape re-form means (28B) for re-forming the beam shape of said second light beam (LB);
a polarizing beam splitter (32) for synthesizing a first light beam outputted from said first anamorphic beams shape re-form means (28 A) and a second light beam outputted from said

second anamorphic beam shape re-form means (28B) which is supplied to said polarizing beam splitter (32) with an incident angle deviated by an angle of 90 degrees relative to the incident angle of said first light beam outputted from said first anamorphic beam shape re-form means (28A) and with a polarizing plane that is orientated at an angle of 90 degrees relative to the polarizing plane of said first light beam outputted from said first anamorphic beam shape re-form means (28A); and a beam converging optical system (34, 35, 36; 44) comprising relay lenses (34, 35) for converging the synthesized light beam outputted from said polarizing beam splitter (32).

2. A laser light source according to claim 1, wherein there is provided a polarizing means (30) for polarizing said second light beam emitted from said second anamorphic beam shape re-form means (28B) such that the polarizing plane of said second light beam emitted from said polarizing means (30) is orientated at an angle of 90 degrees relative to the polarizing plane of said first light beam emitted from said first anamorphic beam shape re-form means (28A).

3. A laser light source according to claim 2, wherein said polarizing means (30) is a halfwave plate.

4. A laser light source according to claim 1, wherein the polarizing plane of said second light beam (LB) emitted from said second light source (22B) is different by an angle of 90 degrees relative to the polarizing plane of said first light beam (LA) emitted from said first light source (22A).

5. A laser light source according to any one of claims 1 to 4, wherein said first and second anamorphic beam shape re-form means (28A, 28B) are anamorphic prisms (25A, 26A; 25B, 26B).

6. A laser light source according to any one of claims 1 to 5, wherein the light beam (LL) outputted from said beam converging optical system (34, 35, 36; 44) is supplied to an optical guide.

7. A laser light source according to claim 6, wherein said optical guide is an optical fiber (40).

8. A laser light source according to claim 7, wherein a plurality of said optical fibers (40A - 40N) are bundled to form a single light source.

9. A laser light source according to claim 2, wherein said first and second anamorphic beam shape re-form means (28A, 28B), said polarizing means (30) and said beam splitter (32) are mounted on a single substrate (41).

10. A laser light source according to claim 9, wherein the beam emitting surface of said first anamorphic beam shape re-form means (28A) is formed integrally with the corresponding beam incident surface of said beam splitter (32).

11. A laser light source according to claim 9 or 10, wherein the beam emitting surface of said polarizing means (30) is formed integrally with the corresponding beam incident surface of said beam splitter (32).

12. A laser light source according to claim 11, wherein the beam emitting surface of said second anamorphic beam shape re-form means (28B) is formed integrally with the corresponding beam incident surface of said polarizing means (30).

13. A laser light source according to claim 4, wherein said first and second anamorphic beam shape re-form means (28A, 28B) and said beam splitter (32) are mounted on a single substrate (41).

14. A laser light source according to claim 13, wherein the beam emitting surface of said first anamorphic beam shape re-form means (28A) and/or the beam emitting surface of said second anamorphic beam shape re-form means (28B) is formed integrally with the corresponding beam incident surface of said beam splitter (32).

15. A solid state laser device comprising:

a laser light source (21) according to claim 1 and
an optical fiber (40) which is supplied with a light beam outputted from said beam splitter (32), wherein a light beam outputted from said optical fiber is supplied to a laser medium to generate a laser light.

Patentansprüche

1. Laserlichtquelle, umfassend

eine erste Lichtquelle (22A) zum Emittieren eines ersten Lichtstrahls (LA) mit einer bestimmten Polarisationsebene,
eine zweite Lichtquelle (22B) zum Emittieren eines zweiten Lichtstrahls (LB) mit einer bestimmten Polarisationsebene,
eine erste anamorphotische Strahl-Umform-vorrichtung (28A) zum Umformen der Strahlform des ersten Lichtstrahls (LA),
eine zweite anamorphotische Strahl-Umform-

vorrichtung (28B) zum Umformen der Strahlform des zweiten Lichtstrahls (LB),
einen Polarisations-Strahlteiler (32) zum Synthetisieren eines von der ersten anamorphotischen Strahl-Umformvorrichtung (28A) ausgegebenen ersten Lichtstrahls und eines von der zweiten anamorphotischen Strahl-Umformvorrichtung (28B) ausgegebenen zweiten Lichtstrahls, welcher dem Polarisations-Strahlteiler (32) mit einem gegenüber dem Einfallswinkel des von der ersten anamorphotischen Strahl-Umformvorrichtung (28A) ausgegebenen ersten Lichtstrahls um 90 Grad unterschiedlichen Einfallswinkel und mit einer gegenüber der Polarisationsebene des von der ersten anamorphotischen Strahl-Umformvorrichtung (28A) ausgegebenen ersten Lichtstrahls mit einem Winkel von 90 Grad ausgerichteten Polarisationsebene zugeführt wird, und
ein optisches Strahl-Bündelungssystem (34, 35, 36; 44) mit Zwischenlinsen (34, 35) zum Bündeln des von dem Polarisations-Strahlteiler (32) ausgegebenen synthetisierten Lichtstrahls.

2. Laserlichtquelle nach Anspruch 1, wobei eine Polarisationsvorrichtung (30) vorhanden ist, um den von der zweiten anamorphotischen Strahl-Umformvorrichtung (28B) ausgegebenen zweiten Lichtstrahl derart zu polarisieren, daß die Polarisationsebene des von der Polarisationsvorrichtung (30) ausgegebenen zweiten Lichtstrahls gegenüber der Polarisationsebene des von der ersten anamorphotischen Strahl-Umformvorrichtung (28A) ausgegebenen ersten Lichtstrahls mit einem Winkel von 90 Grad ausgerichtet ist.

3. Laserlichtquelle nach Anspruch 2, wobei die Polarisationsvorrichtung (30) eine Halbwellenplatte ist.

4. Laserlichtquelle nach Anspruch 1, wobei die Polarisationsebene des von der zweiten Lichtquelle (22B) emittierte zweiten Lichtstrahls (LB) von der Polarisationsebene des von der ersten Lichtquelle (22A) emittierten ersten Lichtstrahls (LA) um einen Winkel von 90 Grad unterschiedlich ist.

5. Laserlichtquelle nach einem der Ansprüche 1 bis 4, wobei die erste und zweite anamorphotische Strahl-Umformvorrichtungen (28A, 28B) Anamorphot-Prismen (25A, 25B; 26A, 26B) sind.

6. Laserlichtquelle nach einem der Ansprüche 1 bis 5, wobei der von dem optischen Strahl-Bündelungssystem (34, 35, 36; 44) ausgegebene Lichtstrahl (LL) einer Lichtleitende Vorrichtung zugeführt wird.

7. Laserlichtquelle nach Anspruch 6, wobei die Lichtleitende Vorrichtung eine Lichtleitfaser (40) ist.

8. Laserlichtquelle nach Anspruch 7, wobei eine Vielzahl von Lichtleitfasern (40A-40N) gebündelt sind, um eine einzige Lichtquelle zu bilden.

9. Laserlichtquelle nach Anspruch 2, wobei die ersten und zweiten anamorphotischen Strahl-Umformvorrichtungen (28A, 28B), die Polarisationsvorrichtung (30) und der Strahlteiler (32) auf einem einzigen Substrat (41) angeordnet sind.

10. Laserlichtquelle nach Anspruch 9, wobei die einen Lichtstrahl emittierende Oberfläche der ersten anamorphotischen Strahl-Umformvorrichtung (28A) mit der entsprechenden den Lichtstrahl empfangenden Oberfläche des Strahlteiler (32) integriert ausgebildet ist.

11. Laserlichtquelle nach Anspruch 9 oder 10, wobei die einen Lichtstrahl emittierenden Oberfläche der Polarisationsvorrichtung (30) mit der entsprechenden den Lichtstrahl empfangenden Oberfläche des Strahlteilers (32) integriert ausgebildet ist.

12. Laserlichtquelle nach Anspruch 11, wobei die einen Lichtstrahl emittierende Oberfläche der zweiten anamorphotischen Strahl-Umformvorrichtung (28B) mit der entsprechenden den Lichtstrahl empfangenden Oberfläche der Polarisationsvorrichtung (30) integriert ausgebildet ist.

13. Laserlichtquelle nach Anspruch 4, wobei die erste und zweite anamorphotische Strahl-Umformvorrichtung (28A, 28B) sowie der Strahlteiler (32) auf einem einzigen Substrat (41) angeordnet sind.

14. Laserlichtquelle nach Anspruch 13, wobei die einen Lichtstrahl emittierende Oberfläche der ersten anamorphotischen Strahl-Umformvorrichtung (28A) und/oder die einen Lichtstrahl emittierende Oberfläche der zweiten anamorphotischen Strahl-Umformvorrichtung (28B) mit der entsprechenden den Lichtstrahl empfangenden Oberfläche des Strahlteilers (32) integriert ausgebildet ist.

15. Festkörperlaservorrichtung, umfassend

eine Laserlichtquelle (21) nach Anspruch 1, und
eine Lichtleitfaser (40), der ein von dem Strahlteiler (32) ausgegebener Lichtstrahl zugeführt wird, wobei ein von der Lichtleitfaser ausgegebener Lichtstrahl einem Lasermedium zur Erzeugung von Laserlicht zugeführt wird.

Revendications

1. Source de lumière laser, comprenant :

   une première source (22A) de lumière destinée à émettre un premier faisceau lumineux (LA) ayant un plan prédéterminé de polarisation,
   une seconde source (22B) de lumière destinée à émettre un second faisceau lumineux (LB) ayant un plan prédéterminé de polarisation,
   un premier dispositif (28A) de transformation par anamorphose de la configuration du faisceau, destiné à transformer la configuration du premier faisceau lumineux (LA),
   un second dispositif (28B) de transformation par anamorphose de la configuration du faisceau, destiné à transformer la configuration du second faisceau lumineux (LB), et
   un répartiteur (32) de faisceau polarisant destiné à synthétiser un premier faisceau lumineux transmis par le premier dispositif de transformation par anamorphose (28A) et un second faisceau lumineux transmis par le second dispositif de transformation par anamorphose (28B) au répartiteur (32) de faisceau polarisant avec un angle d'incidence qui diffère de 90° par rapport à l'angle d'incidence du premier faisceau lumineux provenant du premier dispositif de transformation par anamorphose (28A) et avec un plan de polarisation qui est orienté à 90° par rapport au plan de polarisation du premier faisceau lumineux transmis par le premier dispositif de transformation par anamorphose (28A), et
   un système optique (34, 35, 36 ; 44) destiné à faire converger le faisceau et comprenant des lentilles relais (34, 35) destinées à faire converger le faisceau lumineux synthétisé provenant du répartiteur (32) de faisceau polarisant.

2. Source de lumière laser selon la revendication 1, dans laquelle un dispositif polarisant (30) est incorporé afin qu'il polarise le second faisceau lumineux émis par le second dispositif de transformation par anamorphose (28B) et que le plan de polarisation du second faisceau lumineux émis par le dispositif polarisant (30) soit orienté avec un angle de 90° par rapport au plan de polarisation du premier faisceau lumineux émis par le premier dispositif de transformation par anamorphose (28A).

3. Source de lumière laser selon la revendication 2, dans laquelle le dispositif polarisant (30) est une lame demi-onde.

4. Source de lumière laser selon la revendication 1, dans laquelle le plan de polarisation du second faisceau lumineux (LB) émis par la seconde source (22B) de lumière diffère de 90° du plan de polarisation du premier faisceau lumineux (LA) émis par la première source de lumière (22A).

5. Source de lumière laser selon l'une quelconque des revendications 1 à 4, dans laquelle le premier et le second dispositif de transformation par anamorphose (28A, 28B) sont des prismes anamorphoseurs (25A, 26A ; 25B, 26B).

6. Source de lumière laser selon l'une quelconque des revendications 1 à 5, dans laquelle le faisceau lumineux (LL) transmis par le système optique (34, 35, 36 ; 44) de convergence de faisceau est transmis à un guide optique.

7. Source de lumière laser selon la revendication 6, dans laquelle le guide optique est une fibre optique (40).

8. Source de lumière laser selon la revendication 7, dans laquelle plusieurs fibres optiques (40A-40N) sont regroupées afin qu'elles forment une seule source lumineuse.

9. Source de lumière laser selon la revendication 2, dans laquelle le premier et le second dispositif de transformation par anamorphose (28A, 28B), le dispositif polarisant (30) et le répartiteur de faisceau (32) sont montés sur un seul substrat (41).

10. Source de lumière laser selon la revendication 9, dans laquelle la surface d'émission de faisceau du premier dispositif de transformation par anamorphose (28A) est formée afin qu'elle soit solidaire de la surface correspondante d'incidence de faisceau du répartiteur de faisceau (32).

11. Source de lumière laser selon la revendication 9 ou 10, dans laquelle la surface d'émission du faisceau du dispositif polarisant (30) est formée afin qu'elle soit solidaire de la surface correspondante d'incidence du faisceau du répartiteur de faisceau (32).

12. Source de lumière laser selon la revendication 11, dans laquelle la surface d'émission du faisceau du second dispositif de transformation par anamorphose (28B) est formée afin qu'elle soit solidaire de la surface correspondante d'incidence du faisceau du dispositif polarisant (30).

13. Source de lumière laser selon la revendication 4, dans laquelle le premier et le second dispositif de transformation par anamorphose (28A, 28B) et le répartiteur de faisceau (32) sont montés sur un même substrat (41).

14. Source de lumière laser selon la revendication 13,

dans laquelle la surface d'émission de faisceau du premier dispositif de transformation par anamorphose (28A) et/ou la surface d'émission de faisceau du second dispositif de transformation par anamorphose (28B) sont formées afin qu'elles soient solidaires de la surface correspondante d'incidence de faisceau du répartiteur de faisceau (32).

15. Dispositif laser à semi-conducteur, comprenant :

une source (21) de lumière laser selon la revendication 1, et
une fibre optique (40) qui reçoit un faisceau lumineux provenant du répartiteur de faisceau (32), le faisceau lumineux provenant de la fibre optique étant transmis à un milieu à effet laser pour la création de lumière laser.

FIG. 1

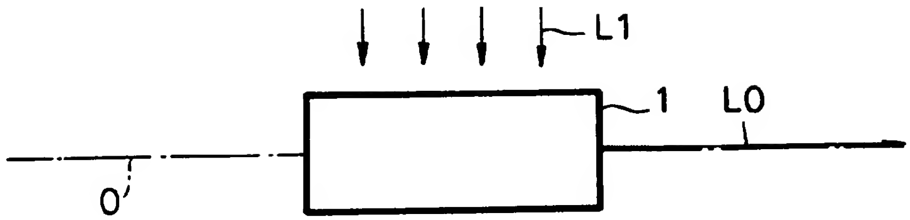


FIG. 2

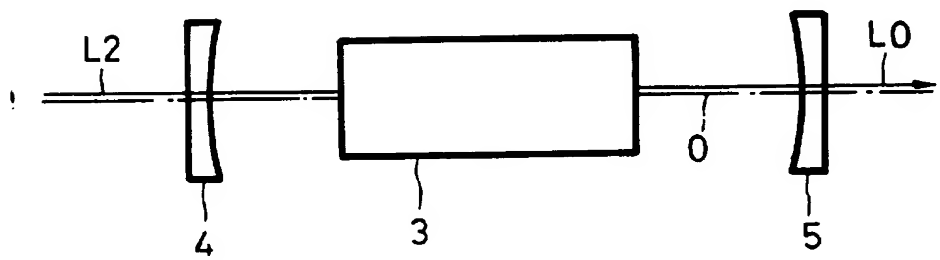


FIG. 3

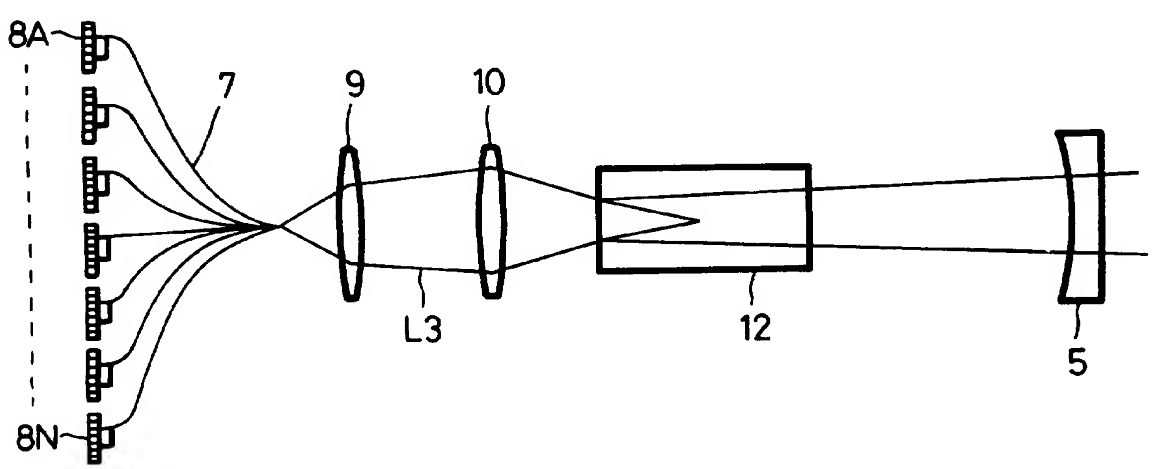
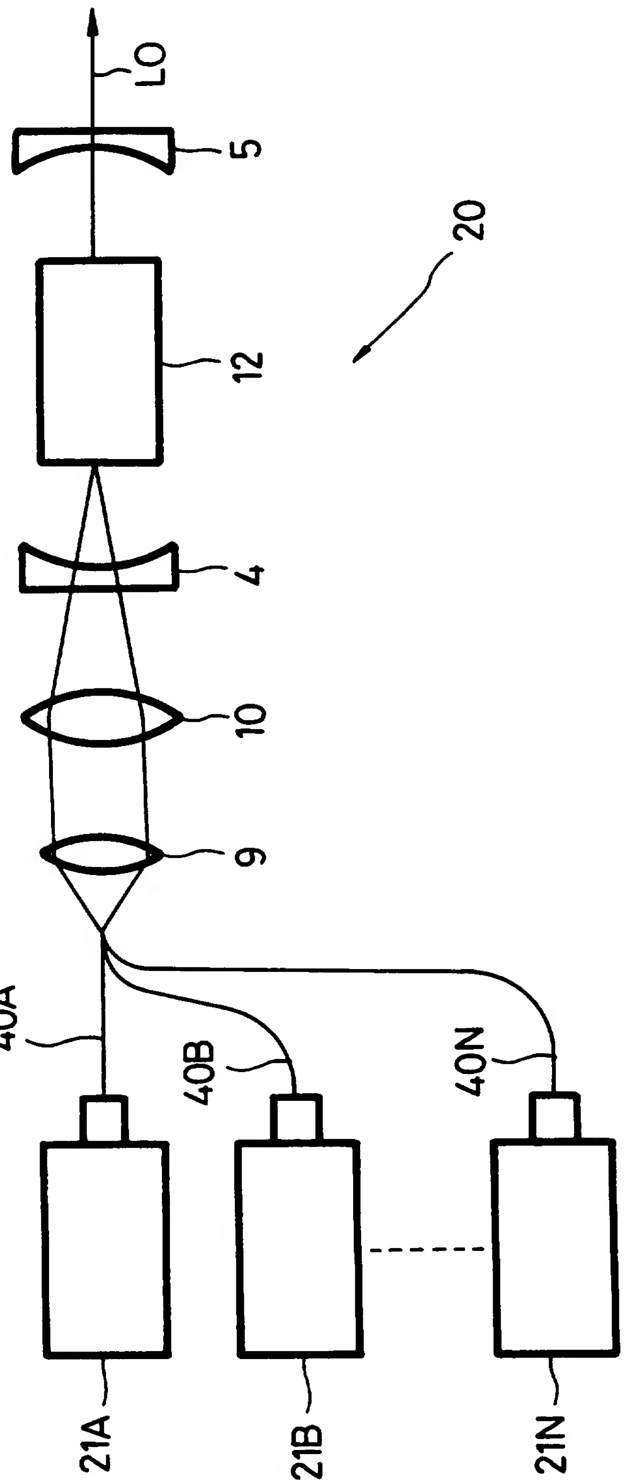


FIG. 4



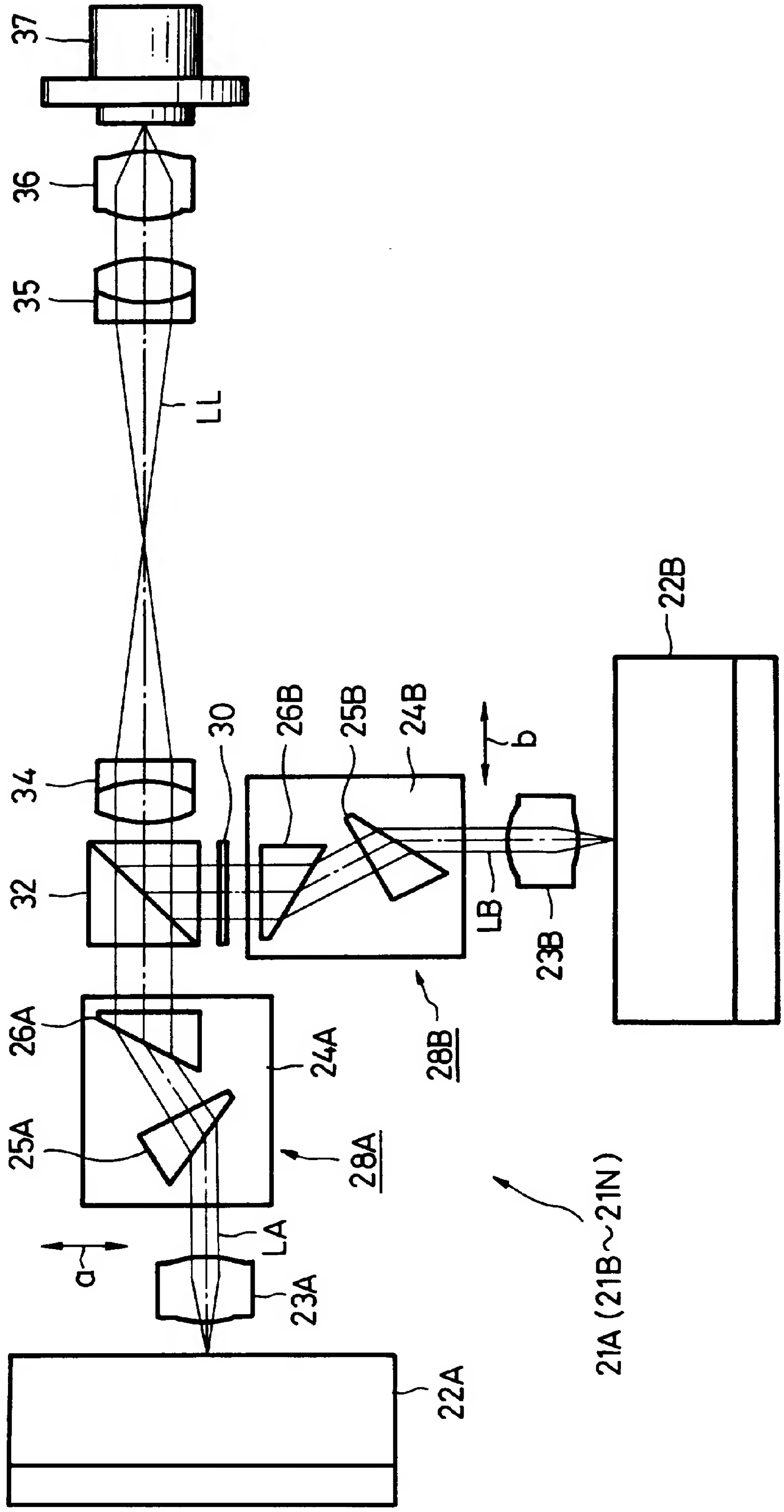

37
36
35
LL
22B
34
30
26B
25B
24B
b
32
LB
23B
26A
24A
28B
25A
28A
LA
a
23A
21A (21B~21N)
22A

FIG. 5

FIG. 6

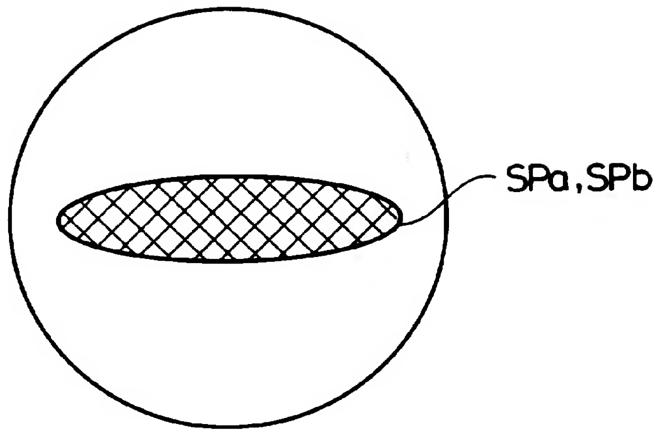

SPa, SPb

FIG. 7

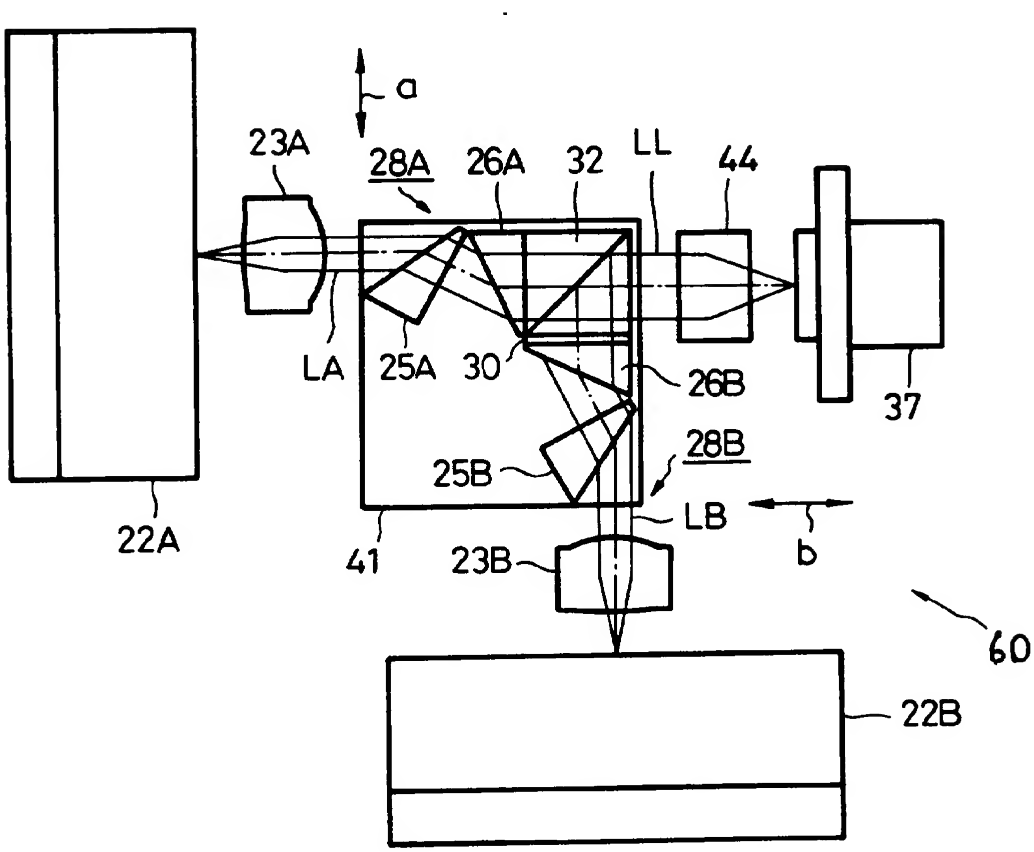

a
23A
28A
26A
32
LL
44
LA
25A
30
26B
37
28B
25B
LB
b
22A
41
23B
60
22B

FIG. 8

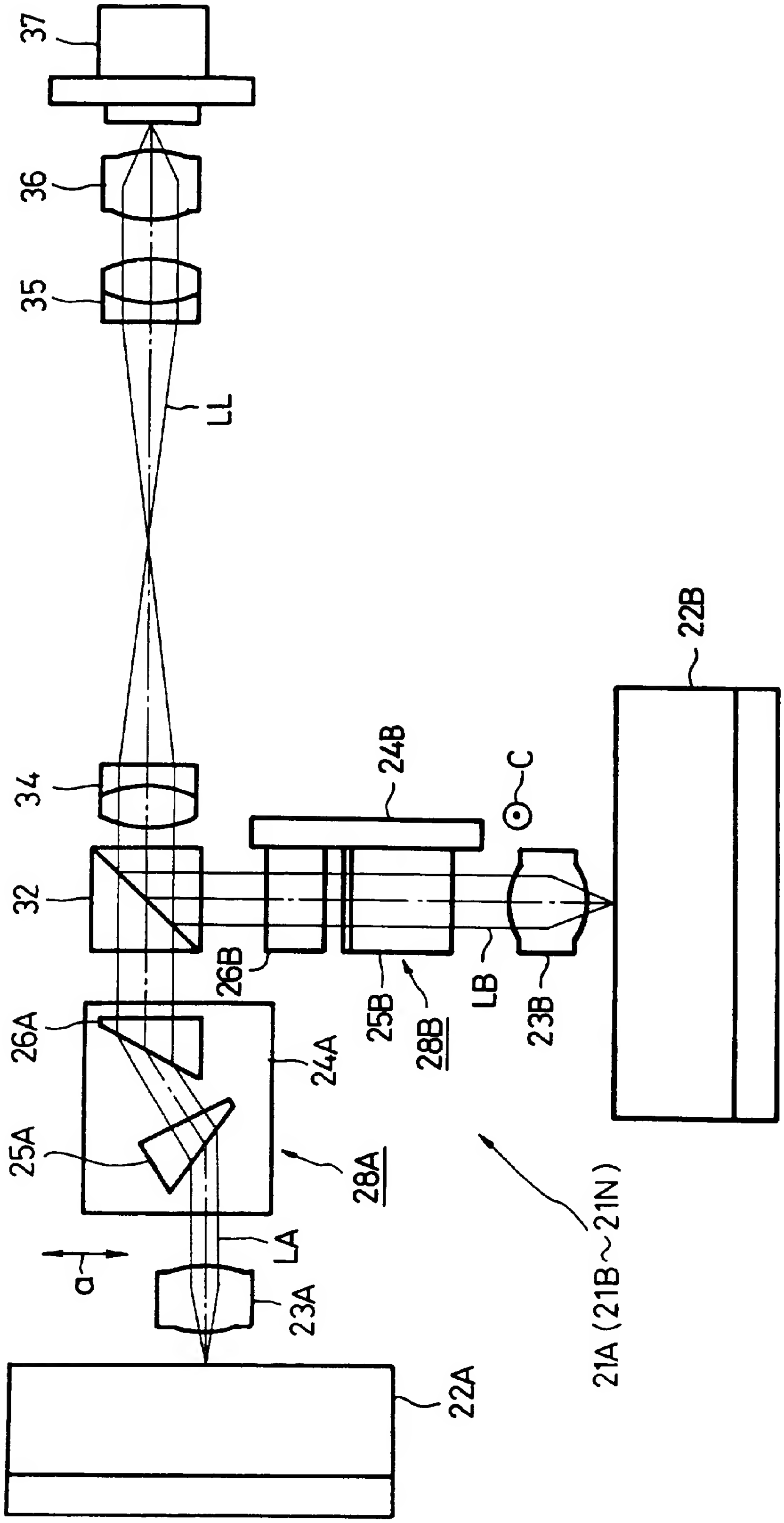

37
36
35
LL
34
32
26A
25A
24A
28A
26B
25B
28B
LB
23B
24B
C
22B
a
LA
23A
22A
21A (21B～21N)

FIG. 9

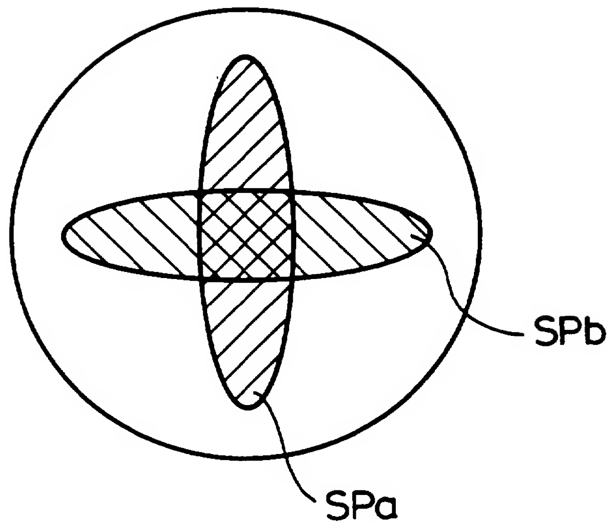


FIG. 10